

II. *Some Remarks on the Allowances to be made in Astronomical Observations for the Refraction of the Air. By Dr. Edm. Halley, R. S. S. Astronomer Royal. With an accurate Table of Refractions.*

WERE the *Medium* of our *Air* much more in Quantity, or the Force of *Gravity* much greater than it is, or in a word, were the Refractive Power of the Air much more sensible than we find it, nothing could have been a greater Impediment to Discoveries in Astronomy: For all Objects appearing by Refraction higher than really they are, till such time as the Laws and Quantity of that Refraction had been ascertained, it would have been impossible to have been secure of the true observed Place of any Cœlestial Object. But as it falls out to be so little, that none but nice Instruments can perceive its Effects, it was not discovered to be at all, till *Bernard Walther's* time, about the Year 1500; nor brought to any sort of Rule till *Tycho Brahe*; nor ascertained, till our worthy *President* made the first accurate Table thereof: The *Curve* which a Beam of *Light* describes, as it approaches the *Earth*, being one of the most perplex and intricate that can well be proposed, as Dr. *Brook Taylor* in the last Proposition of his *Methodus Incrementorum* has made it evident. By this Table it follows that the *ratio*

B b

of

of the Sine of the Angle of Incidence to that of the Refracted Angle, encreasing as the Beam approaches, makes a very notable difference in the place of an Object near the Horizon: but in Objects that are much elevated, the Refractions become small, and their Differences scarce exceed a Second *per* Degree; so that they are sufficiently the same, as if the Incident and Refracted Angles were on the Surface of a Sphere of Air of the same uniform Density close adjoining to the Eye.

When therefore the Stars are twenty degrees or upwards elevated above the Horizon, we may take it for granted, without sensible Error, that the Sines of the true and apparent Distances from the *Vertex*, are in the same constant *ratio*. Hence it will appear that the Distances of all the Stars are seen less than they really are, in whatever position they are taken, and that not less than a Second *per* Degree of the distance; that is, a distance of 30 degrees, for example, is contracted at least so many seconds, and one of 60 gr. no less than a Minute, if the distances be taken by an Instrument that is truly divided. So that when Mr. *Hevelius*, to shew the exactness of his Observations, brings eight Distances, as taken by his *Sextant*, which exactly compleat the Circle, both in Longitude and Right Ascension; the consequence is really quite opposite to his Design: for if those distances were the true ones, they being all contracted by appearing through a refracting *Medium*, the Sum of the eight differences of both Longitude and Right Ascension, ought to fall short of a whole Circle or 360 degrees by at least six minutes; so that I am inclined to believe that the sixty degrees of Mr. *Hevelius's* *Sextant* wanted about a Minute of its true quantity. Such

Such an allowance as this may perhaps be a proper Expedient to avoid accounting for Refraction in cœlestial Observations, provided the Objects be nearly parallel to the Horizon, or at a good height above it. For all distances of Stars are contracted by Refraction, when they are parallel to the Horizon, by the same constant quantity, be they high or low, that is by about one Second *per* Degree; the Chords of the Arches of the real and visible distances being always in the same *ratio* as is the Sine of the Angle of Incidence to that of the refracted Angle.

And this is the case wherein the *Refraction* of the *Air* does least affect the distances of the *Stars*, which Distances are still more and more contracted, as they are nearer to a perpendicular Situation: So that a Distance, for Example, of thirty Degrees loses but half a Minute in a horizontal Site; but if the one Star be 20 degrees high, and the other fifty, it will be lessened by above three times as much, or by 1 m. 41 sec. If the one be 30 and the other 60 Degrees high, the same distance will appear less than 30 Degrees by about one Minute; the difference still decreasing as the Objects are more elevated above the Horizon. But in all cases to account for the effect of the *Refraction* upon the Distances of the Stars, requires, besides some Trigonometrical Work, the help of the afore-mentioned Table, which I here subjoyn for the use of the Curious, such as I long since received it from its Great Author; it having never yet, that I know of, been made publick.

*Tabula Refractionum Siderum ad Altitudines
apparentes.*

Alt. Appar. deg. m.	Refrac- tio. m. sec.	Alt. Appar. deg.	Refrac- tio. m. sec.	Alt. Appar. deg.	Refrac- tio. m. sec.
0 0	33 45	16	3 4	46	0 52
0 15	30 24	17	2 53	47	0 50
0 30	27 35	18	2 43	48	0 48
0 45	25 11	19	2 34	49	0 47
1 0	23 7	20	2 26	50	0 45
1 15	21 20	21	2 18	51	0 44
1 30	19 46	22	2 11	52	0 42
1 45	18 22	23	2 5	53	0 40
2 0	17 8	24	1 59	54	0 39
2 30	15 2	25	1 54	55	0 38
3 0	13 20	26	1 49	56	0 36
3 30	11 57	27	1 44	57	0 35
4 0	10 48	28	1 40	58	0 34
4 30	9 50	29	1 36	59	0 32
5 0	9 2	30	1 32	60	0 31
5 30	8 21	31	1 28	61	0 30
6 0	7 45	32	1 25	62	0 28
6 30	7 14	33	1 22	63	0 27
7 0	6 47	34	1 19	64	0 26
7 30	6 22	35	1 16	65	0 25
8 0	6 0	36	1 13	66	0 24
8 30	5 40	37	1 11	67	0 23
9 0	5 22	38	1 8	68	0 22
9 30	5 6	39	1 6	69	0 21
10 0	4 52	40	1 4	70	0 20
11 0	4 27	41	1 2	71	0 19
12 0	4 5	42	1 0	72	0 18
13 0	3 47	43	0 58	73	0 17
14 0	3 31	44	0 56	74	0 16
15 0	3 17	45	0 54	75	0 15